Face Detection using Color based method with lighting compensation scheme

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by

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Certificate

This is to certify that the report entitled, ***Face Detection using color based method with lighting compensation scheme*** by *Chaluvadi Venkata Sainath* is a record of his research work carried out under my supervision and guidance in partial fulfilment of the requirements for the award of the degree of *Bachelor of Technology Degree* in *Computer Science* and *Engineering* at *National Institute of Technology, Rourkela.*

Pankaj Kumar Sa

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Ch.Vekata Sainath

Abstract

Now-a-days, face detection has attracted more attention and its research has rapidly expanded by not just engineers, but also some neuroscientists, as it has so many applications in the computer vision communication and automated access control system and also some computer enthusiasts like social networking sites to add some more features to their site. It also plays an important role in many applications like face-tracking, face image database management, video surveillance, that can be so much helpful in many cases like, in finding convicts or suspects, social networking sites etc. However, face detection is not straightforward as it has lots of variations of image appearance, like variation in pose (front, non-front), lighting conditions, occlusion, image orientation, and facial expression.

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Chapter 1

Introduction

1.1 Face Detection

Face detection is the computer technology that is used to detect faces in an image. It is one of the most important technologies that has been highly researched during these days. It detects faces and ignores everything else like buildings, and other things. In object-class detection, the task is to find the locations and sizes of all objects in an image that belong to a given class. Examples include upper torsos, pedestrians, and cars. Thus, it can also be regarded as a specific case of object-class detection.

1.2 Motivation

Image Processing is a form of signal processing for which the input is an image such as a photo or frame of a video; the output of it will be either an image or a set of parameters related to the image. Face detection is a computer technology that detects the location of faces in an image irrespective of the presence of any other things, like buildings, furniture, bodies, and trees. The concept of 'face detection' in an image is the classification of image pixels into face pixels and non-face pixels. In the procedure, every pixel of the image is processed and analyzed for the facial features. The task of it is to find the locations and details of all objects that belong to a given class which is why it can also be regarded as a specific case of object-class detection.

1.3 Literature Survey

A survey of various image processing techniques from Research journals and online materials is done before the commencement of the project. The major activities of Literature Survey are described below.

The paper titled "Detection of Faces of Various Directions in Complex Backgrounds" by Yuichi Araki, Nobutaka Shimada, and Yoshiaki Shirai, was surveyed to study about the the detection of faces in complex backgrounds where their sizes, positions and directions are arbitrary. We detect the faces by extracting face components such as eyes, a mouth and so on.

The paper titled "A Simple And Accurate Color Face Detection Algorithm in Complex Background" by Yu-Ting Pai, Shanq-Jang Ruan, and Mon-Chau Shie, Yi-Chi Liu, was surveyed to study about the methods and algorithms to be implemented in order to detect skin and then the facial features and then from them the faces in the image.

The article "Face detection" by Inseong Kim, Joon Hyung Shim, and Jinkyu Yang, was surveyed to know the steps that are needed to detect faces in an image that gave complete view of what should be done in order to detect faces in an image.

The paper "A Real-time Model for Multiple Human Face Tracking from Low-resolution Surveillance Videos" by Rajib Sarkar, Sambit Bakshi, and Pankaj K Sa, gave the complete insight about the method to be followed to detect faces in an image. The paper presents detailed description about the skin detection, extracting facial features and thereby, detecting the faces.

1.4 Objectives and Scope of Work

The research was carried out with the following objectives

- To implement skin detection algorithms:
  - Skin detection using Color-Based Image Retrieval (CBIR) technique
  - color-based method using lighting compensation technique
- To detect faces in an image

Face detection from an image has been a challenging area of research due to the variability of human face with skin-color (like pinkish, yellowish, brownish), pose (like close, distant; front, non-front; orientation), expression (like crying, happy, angry), illuminating conditions (like lighting conditions, day and night time capture), occlusion (like long-hair, interception by another person). Face detection has many applications like:

- Face- Recognition systems
- Person-tracking in Surveillance videos
- Biometrics
- Photography
- Social Networking Sites

1.5 Outline of the Thesis

This thesis consists of the below chapters following this chapter:

Steps in detecting face

An Introduction to face detection and a basic level description of the basic procedure that is to be followed in order to detect faces in the given image.

Methods to detect skin

The details of the methods and their implementations that can be used in order to detect skin in an image are discussed in this chapter.

Implemetation of algorithms to detect skin

This chapter include the Implementation of the algorithms that were discussed in the previous chapter.

Facial Feature Extraction

A brief description of how to extract the facial features in an image after detecting skin in the given image.

Detection of faces

The details of the identification of the facial features with the help of the method described in the previous section to detect faces in the given image.

Results

This chapter discusses the implementation results of various approaches.

Conclusion and Future Work

This chapter discusses the result of the project and future work options.

Chapter 2

Steps in detecting face

For the auto-detection of skin in the images, the following things should be focused:

- Skin Color
- Image Segmentation
- Remove Noise

2.1 Skin Detection

Skin color is the most important thing to be focused as it varied from region to region. Then the image should be segmented so that we can work on small parts individually without much complexity. Even though the skin is detected, there will be so much noise still present in the iamge and hence it should be removed or at least, it should be decreased. If skin detection is done with high-accuracy, it can be used in many cases like face recognition, person tracking etc. Major motivations that all methods to detect skin try to solve or remove them are:

- At low false detection rate, very low false rejection rate
- Identifying the skin color types and kinds
- Handling the ambiguity between the non-skin and skin colors
- Robustness to variation in the illumination conditions
- Insensitivity to face orientation and noise

2.2 Skin detection using Color-Based Image Retrieval (CBIR) technique

In this approach [4], firstly a set of features is defined by CBIR technique and histogram analysis, and then by doing image tiling and using a train level, a threshold is identified for classifying the pixels.

2.2.1 Feature Extraction

It uses a feature vector that defines the features of the total image. In this way, the total histogram of an image is individually extracted and normalized in each of the color channels such as green, red and blue. Then every bin of histogram di considered as a dimension of the feature vector and the height of bin will be the value of that dimension. So, we have a feature vector (say F) with 256*3 dimensions. As experimental results say that vector F, taking in this way couldn't be able to provide sufficient discrimination as the values of those vector F in every dimension is too small. Hence, the vector F is quantized and changed into F' by defining the dimension of F' as the sum of N dimension values from vector F. So, for example if we take N=16, then F' will have 16*3 dimensions.

$$F =< H_{i1}, H_{i2}, H_{i3}, ..., H_{i256} >$$

$$F' = \sum_{i=1}^{N} H_i, \sum_{i=N+1}^{2N} H_i, ..., \sum_{256-N}^{256} H_i$$

where, H is the histogram of image in each channel. So, i means the Red, Green and Blue channels which all of them should compute.

2.2.2 Extraction of average Feature Vector

We define a feature vector F' for every image, that will work as a good identification of that image, and we can use that F' to detect skin. A train stage is needed in order to make the F' vector to be a good identification of skin image. Firstly, in the train stage, some images are taken with only skin portion will be prepared which are called Pure Skin images. Then, F' is calculated for each of those pure skin images and finally an average of all those feature vectors F' will be computed. Now, this average vector will work as a good identification of skin.

$$F_{avg} = \sum_{i=1}^{M} F'_{i,j}$$

Where, M is the number of train images and F' is the feature vector of M^{th} image. In this technique, it also considers the relation between each pixel with its neighborhoods.

2.2.3 Image Tiling

Image tiling is the process of tilting each of the training images into windows of the same dimensions. Now using this feature vectors of all the windows, we will calculate the distance D, between each of the windows and F_{avg}

$$D = distance(F_{image}, F_{avg})$$

$$\begin{aligned} \text{SkinDetection} &= \text{Skin, if } D \leq T \\ &= \text{Non-Skin,else} \end{aligned}$$

Where, D is the distance amount which is the similarity criteria. T is threshold for skin which is the greatest obtained distance of the train images which is describe in the next section. We use Gower distance in our method.

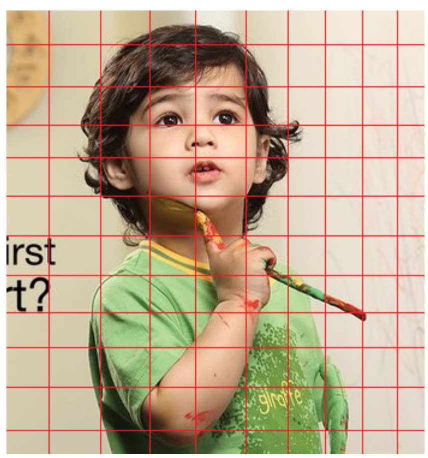

Figure 2.1: Example of Image Tiling

2.2.4 Finding Threshold for skin

For threshold, every pure image is tiled into windows and feature vector of each and every window, and then the distance between the feature vector of every window and average feature vector is calculated. The greatest obtained distance is then taken as the threshold for skin.

Implementation:[4]

- Find the feature vector of the input image.
- Calculate the average feature vector from the train images.
- Image Tiling.
- Find the distance between the feature vector of the each of the image windows and the average feature vector.
- Calculate the threshold value for skin from the feature vector distances of the windows of train images.
- Classify the image pixels into skin or non-skin using the threshold.

2.3 Color based technique with lighting compensation scheme

Color-based method is hard to detect the skin-color for different lighting conditions and feature-based detection has high computational complexity. In this method, we use a lighting compensation scheme [2] that overcome the problem of color-based method and decrease the computational complexity of feature-based method.

2.3.1 Color space transformation and lighting compensation

In this approach, firstly the given image is converted to YC_bC_r color space from RGB color space. Because YC_bC_r color space transform is faster than any other transforms. But the luminance of each and every image will be different which implies that every image has different color distribution. Thus, this lighting compensation is done based on the luminance to modulate the range of skin-color distribution of the images. First, we compute the average luminance Y_{avg} of input image.

$$Y_{avg} = \sum Y_{i,j}$$

Where, $Y_{i,j}$ is luminance of the $(i,j)^{th}$ pixel of the image and Y_{avg} is the average luminance of the image. Then, $Y_{i,j}$ is normalized to the range (0,255), and i, j are the index of pixel. Now, all the regions or connected components that are left in the FM contains the facial features. According to Y_{avg}, we can determine the compensated image $C_{i,j}$ by the following equations:

$$R'_{i,j} = (R_{i,j})^{\tau}$$

$$G'_{i,j} = (G_{i,j})^{\tau}$$

$$C_{i,j} = (R'_{i,j}, G'_{i,j}, B)$$

Now that, we had compensated the values of R and G to make the computation easier. Now the skin-map of $C_{i,j}$ is defined as :

$$\begin{aligned} S_{i,j} &= 0, \text{ if } \tfrac{R+1}{G+1} > 1.08 \ \& \ \tfrac{R+1}{B+1} > 1.08 \ \& \ G > 30 \ \& \ G < 140 \\ &= 1, \text{else} \end{aligned}$$

where, $S_{i,j} = 0$ and $S_{i,j} = 1$ represent the skin-pixel and the non-skin pixel respectively.

Implementation:[1]

Input: RGB image I of size m x n and

Output: Binary image S indicating skin-map

Algorithm 1 : SkinDetection

1: Transform the input mage I from RGB color space to YC_bC_r color space

2: Compute the average luminance value Y_{avg}

$$Y_{avg} = \sum Y_{i,j}$$

3: Normalize the values of $Y_{i,j}$ to [0,255]

4: Brightness compensated image is obtained as $C_{i,j} = (R'_{i,j}, G'_{i,j}, B)$ where,

$$R'_{i,j} = (R_{i,j})^{\tau}$$

$$G'_{i,j} = (G_{i,j})^{\tau}$$

5: The skin map $S_{i,j}$ is obtained from $C_{i,j}$ as:

$$\begin{aligned} S_{i,j} &= 0, \text{ if } \tfrac{R+1}{G+1} > 1.08 \ \& \ \tfrac{R+1}{B+1} > 1.08 \ \& \ G > 30 \ \& \ G < 140 \\ &= 1, \text{else} \end{aligned}$$

where, $S_{i,j} = 0$ and $S_{i,j} = 1$ represent the skin-pixel and the non-skin pixel respectively.

2.4 Removal of Noise

To remove high frequency noise fastly, we can implement a low pass filter by a 5 5 mask. Firstly, we segment the skin map into 55 blocks, and then find the number of white points in a block. Then, every point of a 5 5 block is set to white point when the number of white points is greater than half number of total points. Similarly, if the number of black points is greater than half number of total points, that 5 5 block is modified to a black block completely. Although this method will bring block effect, it can be disregarded as our target is to find the human skin.

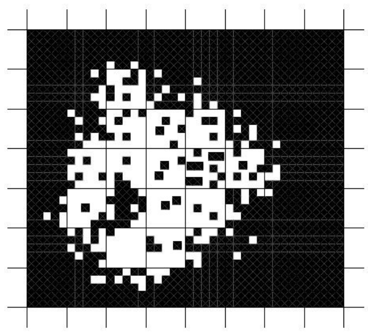

Figure 2.2: Before Removal of Noise

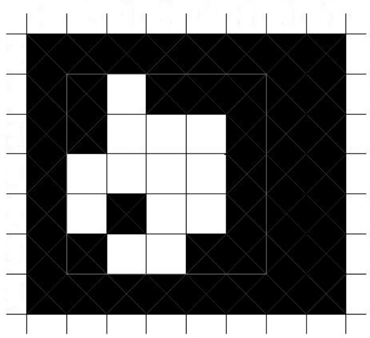

Figure 2.3: After Removal of Noise

2.5 Image Segmentation

In computer vision, it is the process of partitioning a digital image into multiple segments. The main objective of image segmentation is to change or simplify the representation of an image into something that is easier to analyze and more meaningful. To locate objects and boundaries in the images, it is typically used. In short and precise manner, the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics is known as image segmentation. Thus, the main objectives of image segmentation is to first decompose the image in such a way so that we can extract and process only the required features of an image, and then, change the representation of the image so that it is useful for further processing.

2.6 Extraction of Facial Features

After image segmentation, the facial features like mouth, eyes, and nose are to be extracted from the segmented regions by some method and in turn, use them to locate the faces in the image.

The skin regions in the input image has been detected, the facial features in the image should be extracted. Facial features include nose, eyes and mouth.

(Removal of Non-Facial regions) Now, the regions not having any of the pixels of mouth or eyes (facial features) can be eliminated from the scope of observation by the following algorithms[1].

Input: S and Output: MM

Algorithm 2 : MouthDetection

1: For each connected component MC_i in S, repeat step2

2: For each pixel in MC_i repeat steps 3 and 4

3: Calculate $\Theta = \cos^{-1}\left(\frac{0.5(2R'-G'-B)}{\sqrt{(R'-G')^2+(R'-B)(G'-B)}}\right)$

4: Calculate MB_i =0, if $\Theta < 90$

MB_i= 1, else

where, MB_i=0 and MB_i=1 indicates mouth region and non-mouth region respectively.

5: MM=1 [size of the array EM is equal to that of MC

6: If all pixels in B_i is 1 for a particular i, MM_i=0

Input: S and Output: EM

Algorithm 3 : EyeDetection

1: For each connected component MC_i in S, repeat step2

2: For each pixel in MC_i repeat step3

3: Calculate $EB_i = 0$, if $65 < Y < 80$

EB_i= 1, else

where, EB_i=0 and EB_i=1 indicates eye region and non-eye region respectively.

4: EM=1 [size of the array EM is equal to that of MC

5: If all pixels in EB_i is 1 for a particular i, EM_i=0

2.7 Detection of faces:

Algorithm [1] to detect faces after removing the non-facial regions in the detected skin is given below:

Input: S and Output: FM

Algorithm 4 : FaceDetection

1: FM=S

2: MM=MouthDetection(S)

3: EM=EyeDetection(S)

4: For each connected component in S, repeat steps 5 and 6

5: If MM_i=0 and EM_i=0

6: FM=FM-i^{th}component in FM

Now, in the regions that are remaining in FM, eyes and mouth are detected and then the centers of left eye, right eye, and the mouth are detected and then the angle between the line joining the centers of the left eye and right eye, and the line perpendicular to the center of the mouth is taken as alpha indicating the angle the face is making with the horizontal axis.

Chapter 3

Results

3.1 Skin detection using Color-Based Image Retrieval (CBIR) technique

Figure 3.1: Original Image

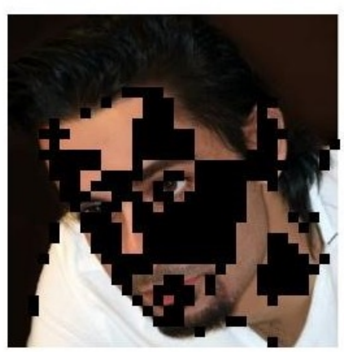

Figure 3.2: Skin Detected Image

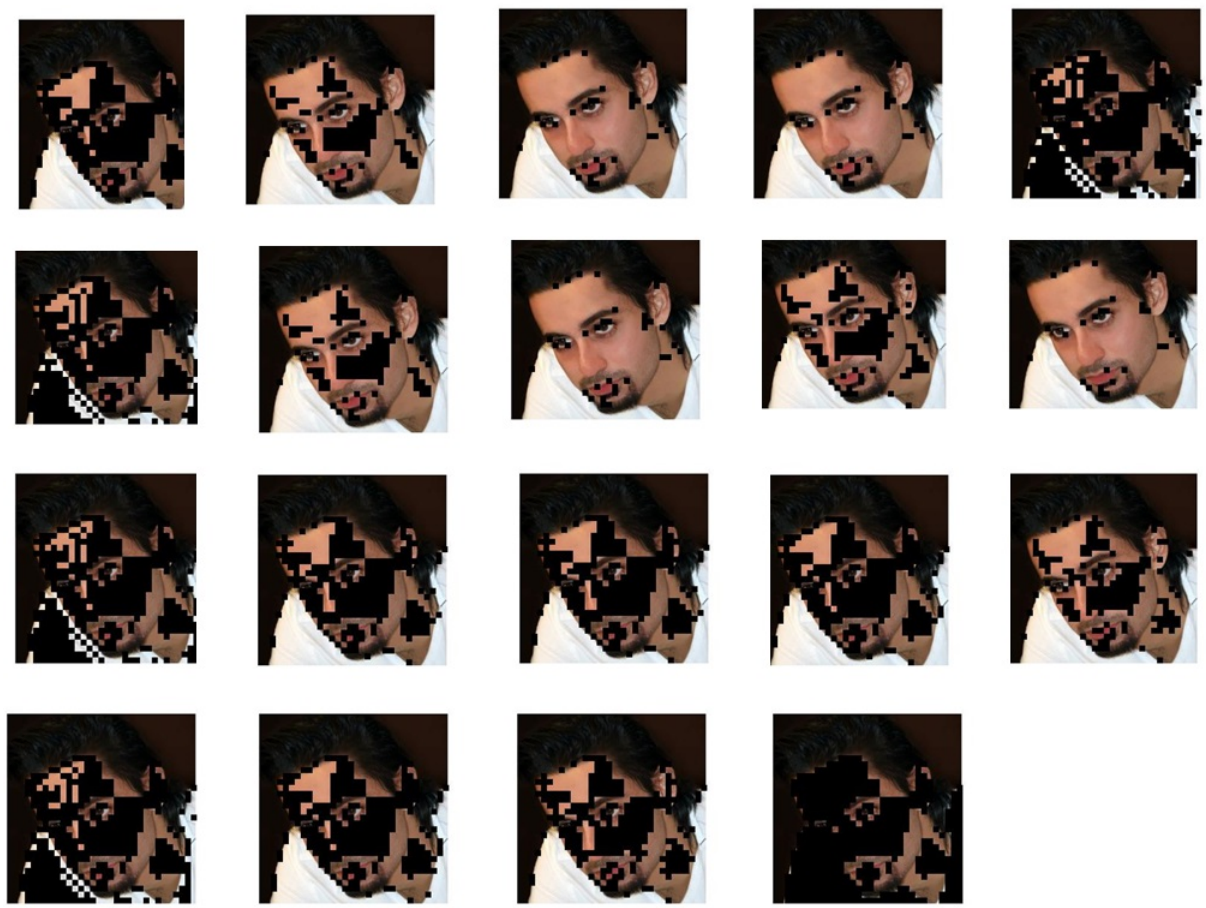

Figure 3.3: Results for different training sets

3.2 Color based technique with lighting compensation scheme

Steps in the algorithm:

Figure 3.4: Example-1 : (a) original image, (b) input image in YCbCr color space, (c) brightness compensated image of the input image, (d) skin map of input image, (e) skin map of input image after noise removal, (f) Final ouput image with the detected faces

Figure 3.5: Example-2 : (a) original image, (b) input image in YCbCr color space, (c) brightness compensated image of the input image, (d) skin map of input image, (e) skin map of input image after noise removal, (f) Final ouput image with the detected faces

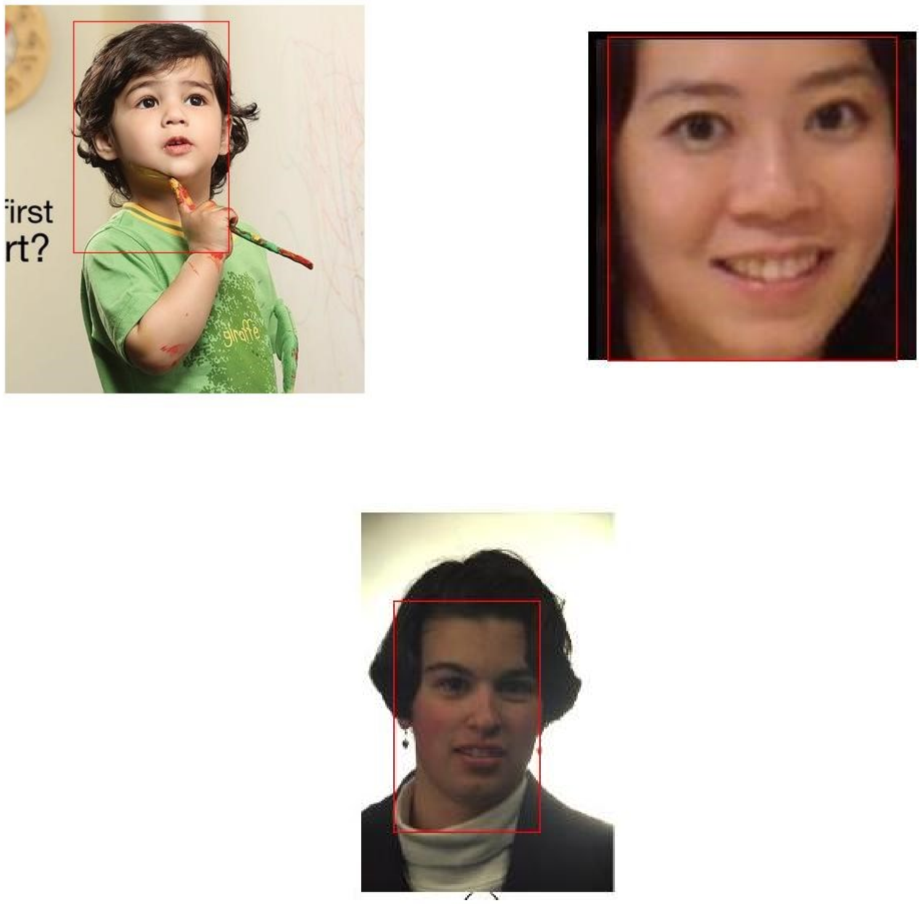

Figure 3.6: Some other results

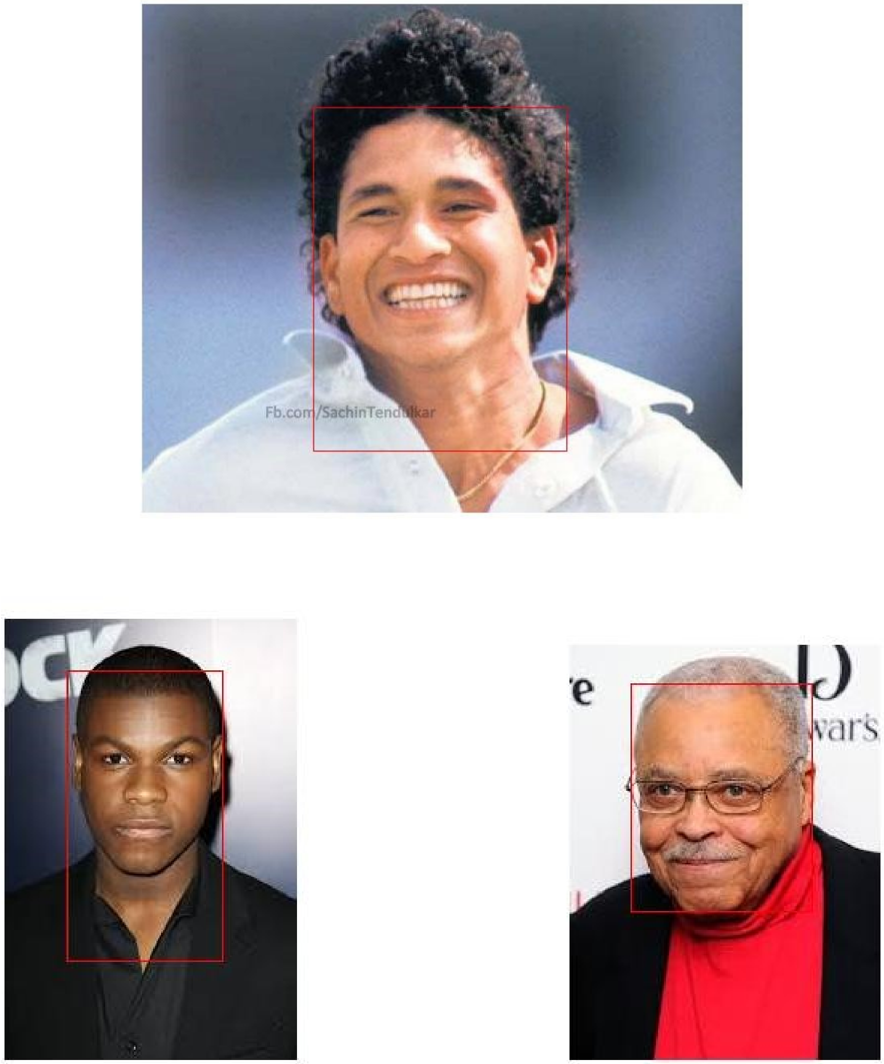

Figure 3.7: Some other results

Chapter 4

Conclusion and Future Work

In this thesis the discussed approaches for face detection are implemented and the results are analyzed. Outputs of those implementations have been shown and tried for different threshold values and other parameters.

In future, this work can be extended by developing a method that can be applied to any image irrespective of the illumination conditions and other problems that are common in the face detection in an image like orientation of faces, poses etc.

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